

PRIORITY IN THE INVENTION OF RADIO

TESLA VS. MARCONI

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LELAND ANDERSON

TECHNICAL EDITOR

Colorado School of Mines Research Institute

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Despite the fact that a U.S. Supreme Court decision in 1943 invalidated the fundamental radio patent of Marconi, there persists continuing argument asserting Marconi's priority. These arguments ignore not only the opinion of the Court, but as well the enormous body of testimony by experts in the field of radio that support it. The purpose of this paper is to extract from the Transcript of Record and the Opinion for the case the essential elements which were in dispute in an attempt to answer the continuing arguments.

In numerous articles and press statements during the period when practical wireless communication and radio broadcasting was emerging (from just before the turn of the century through the 1920s) Tesla claimed the invention of radio. A news item appearing in the *New York Times* for August 4, 1915, was the culmination of those assertions: "TESLA SUES MARCONI ON WIRELESS PATENT; Alleges That Important Apparatus Infringes Prior Rights Granted to Him." Tesla at that time had just reached a disastrous financial impasse. The mortgage on his laboratory and plant at Wardencllyffe, Long Island, had gone into foreclosure and he was unable to mount the considerable financial resources necessary to press the case. However, the federal government took note of this complaint when, on July 29, 1916, the Marconi Wireless Telegraph Company of America brought suit in the U.S. Court of Claims for damages in amount of \$42,984.93, alleging that the U.S. had used wireless devices during WWI that infringed on Marconi's patent (#763,772 June 28, 1904). The attorneys for the

Prior to joining the Colorado School of Mines Research Institute, Mr. Anderson served as an independent consultant to the energy and environmental control industries following positions of senior design engineer and senior market analyst for Sperry Univac in St. Paul, Minnesota. Mr. Anderson has studied the historical development of telephone and radio communications from a technology standpoint for the past 25 years. His most recent slide-talk on the history of high-frequency, high-voltage techniques was given at the National Bureau of Standards laboratories in Boulder, Colorado.

Mr. Anderson is a senior member of the IEEE, and has been a member of the A.W.A. since 1967. His home is in Denver, Colorado.

government chose to use the Tesla system patent (#645,576 March 20, 1900) and its subdivision patent for apparatus (#649,621 May 15, 1900), the Stone patent embracing greater tuning selectivity (#714,756 December 2, 1902), and the Lodge patent providing variable inductance tuning (#609,154 August 16, 1898) as the basis to contest the claim of the Marconi Company.

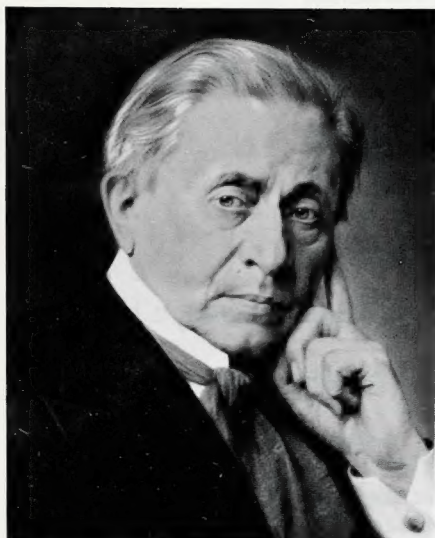


Figure 1 — JOHN STONE STONE (1869-1943). Provided mathematical insight into operation of four-tuned coupled circuits.



Figure 3—MARCHESE GUGIELMO MARCONI (1874-1937). Questions have recently been raised about his transatlantic signaling apparatus.

(Photo courtesy The Bettman Archive.)

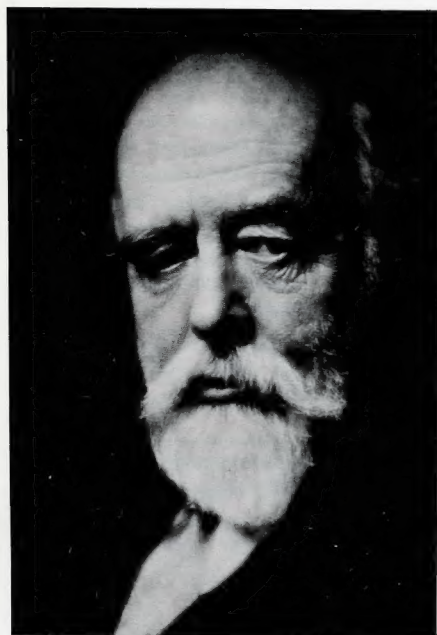


Figure 2 — SIR OLIVER LODGE (1851-1940) Disclosed variable inductance tuning in his patent application.

In a discussion of priority in the invention of radio, one must be very specific about definitions. In the previously cited case of the Marconi Wireless Company of America vs. United States (which was decided June 21, 1943 against the Marconi Company and striking down the fundamental Marconi patent¹), the following

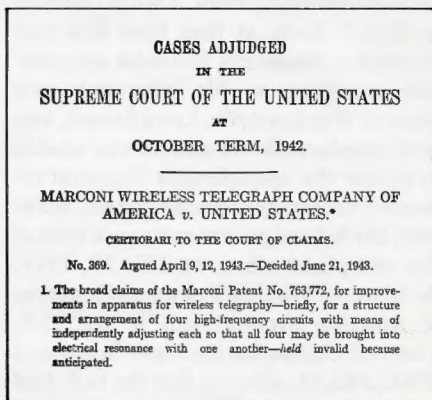


Figure 4 — Eleventh wireless telegraphy patent to be brought before the U. S. Supreme Court.

definition evolved out of the exhaustive depositions taken from many technical experts in the fields of radio and the physical sciences:

A radio communication system requires two tuned circuits each at the transmitter and receiver, all four tuned to the same frequency. The definition does *not* embrace variable modulation that de Forest's audion provided and through which the transmission and reception of voice and music was made possible. It does *not* address the mode of electromagnetic propagation --that is, ground wave and/or sky wave and the effect of the former on the latter. It does, however, implicitly describe the deliberate, selective transmission at a specific frequency and the selectable reception at that same frequency.

The original application for the Marconi patent (#763,772) was filed on November 10, 1900, and rejected on the prior art disclosed by Lodge. On July 1, 1901, the entire original specification and all of the claims were cancelled and a new specification and set of claims substituted. The Examiner who first handled these applications, and continued to handle them for more than three years, repeatedly and consistently rejected them on the prior art of Tesla, Lodge and Braun. In reply to an amendment then furnished by Marconi, the Patent Office again rejected on June 3, 1902, all of the claims on the Tesla patent #645,576 and its subdivision #649,621 because Tesla showed "...an electrical oscillator comprising an alternating current generator charging a condenser and an interrupter, which is a spark gap, for discharging the same. The primary of a transformer (the "Tesla coil") is fed by this oscillation producing circuit. The secondary is connected to the ground at one end and to an elevated conductor at the other."² The Examiner also contended that there could be no novelty in merely providing two circuits having their fre-



Figure 5 -- NIKOLA TESLA (1856-1943)
First to disclose and demonstrate basic four-tuned coupled circuits.

quency adjustable. Tesla had shown these circuits and provided for their adjustment in general language, and there could be no novelty in specifically claiming the adjustable elements as Lodge and Marconi himself (in a non-dual tuned circuit patent) had previously disclosed these. The Examiner stated: "Since it is impossible to exactly calculate the values of the electromagnetic constants of two circuits for the purpose of making their time period agree, it is fair to assume that the electrical oscillator of Tesla must necessarily be made with an adjustable inductance or condenser, or both."³

This Patent Office action of June 3, 1902, resulted in Marconi letting his application become abandoned, for no reply was made within the year required under the Patent Office rules.

On October 6, 1903, 16 months after the Office letter rejecting the case, Marconi filed a petition to the Commissioner of Patents for revival of the case, together with a proposed amendment and reply to the Examiner's arguments on rejection. On October 15, 1903, the Examiner, in a statement to the Commissioner, recom-

mended that the petition for revival be denied. He persisted in his contention that the claims were not patentable over Tesla, and further adds prior art disclosed in a paper by Michael Pupin presented before the American Institute of Electrical Engineers in December, 1899, and the Stone patent #714,756. In the words of the Examiner, "Many of the claims are not patentable over Tesla #645,576 and 649,621, of record, the amendment designed to overcome said references as well as Marconi's pretended ignorance of the nature of a 'Tesla oscillator' being little short of absurd. Ever since Tesla's famous lecture on alternating current of high frequency delivered before the American Institute of Electrical Engineers in 1891, and repeated in 1892 before the Institute of Electrical Engineers and the Royal Institution, London, the Societe Internationale des Electriciens, and the Societe Francaise de Physique, Paris, which lectures have been widely published in all languages, the term 'Tesla oscillator' has become a household word on both continents."⁴

The Examiner further points out that this Tesla oscillator was found in all elementary textbooks used in the ordinary high schools, and that Marconi evidently knew of it in 1897, because he (Marconi) is quoted by Della Rictia in a publication in 1898 as having used it.

Additional affidavits were filed by Marconi subsequent to the Examiner's statement, and these were considered by the Examiner. In a statement to the Commissioner his recommendation for denial of the petition was persisted in. On December 3, 1903, the Commissioner formally denied the petition for revival.

On February 19, 1904, Marconi requested a reconsideration of the petition, which petition was surprisingly granted on March 28, 1904, by the Commissioner of Patents. There was no evidence in the file to indicate that the petition had

been submitted to the Examiner for consideration, and no statement from the Examiner to the Commissioner commenting on the petition. Following the revival of the application, the case was given to a different Examiner and immediately acted upon.⁵ The Marconi application was granted on June 28, 1904, as patent #763,772.

The Court, in its opinion, noted that it is not without significance that Marconi's patent was also rejected by the Patent Office because anticipated by Stone, and was ultimately allowed, on revival of his application, on the sole ground that Marconi showed the use of a variable inductance as a means of tuning the antenna circuits, whereas Stone, in the opinion of the second Examiner, tuned his antenna circuits by adjusting the length of the aerial conductor. All of Marconi's claims which included that element were allowed, and the second Examiner stated that the remaining claims (four) would be allowed if amended to include a variable inductance. Apparently through oversight, Claims 10 and 11, which failed to include that element, were included in the patent as granted. In allowing these claims the second Examiner made no reference to Lodge's prior disclosure of a variable inductance in the antenna circuit (patent #609,154).⁶

At this point it would be well to dispose of one recurring criticisms of Tesla's priority in invention of radio before taking up those criticisms examined by the Court, and that criticisms pertains to the requirement for a ground connection to one of the high frequency transformer secondary terminals (the antenna being connected to the other). Critics that contend Tesla did not show this clearly dismissing his lectures, writings, and patent(s) which specifically identify a ground connection. Tesla delivered before the Franklin Institute, Philadelphia, February 24, 1893, a lecture on "Light and

Other High Frequency Phenomena," as reported in a book entitled "Inventions, Researches, and Writings of Nikola Tesla," by Martin, published in 1894, and in numerous technical journals of the period. Investigations of Hertz disclosed that in order to create energy-bearing waves it was necessary to produce high frequency currents or rapid electrical oscillations. Martin's book, beginning at page 302, and particularly in connection with Figure 165, shows how to produce such currents or oscillations using ordinary dynamo machines. Various applications to which the high frequency currents produced by the system illustrated in Figure 165 are described, and on page 346 Tesla definitely proposes the production of electric waves by such currents for the transmission of telegraph messages without wires. On page 348, in connection with Figure 185, Tesla suggests an electromagnetic wave producing system in association with a

source of high frequency currents, a system comprising an elevated conducting surface connected to one of the terminals of the source, the other terminal of the source being connected to the earth or water mains presumably buried in the earth. It is reasonable to associate the system in Figure 185 with any one of the numerous systems illustrated in Figure 165 for producing high frequency currents.⁷

The lectures of Tesla in 1893 and Martin's book on Tesla in 1894 attracted widespread attention, some of which is indicated by the following expressions from two persons skilled in the art: A.A.C. Swinton in the *Electrician*, London, October 22, 1897, page 869, calls attention to Martin's book of 1894, pages 346 and 349, and accords to Tesla credit for a share in the work of bringing about practicable and commercial wireless telegraphy. Professor S. E. Thompson in his

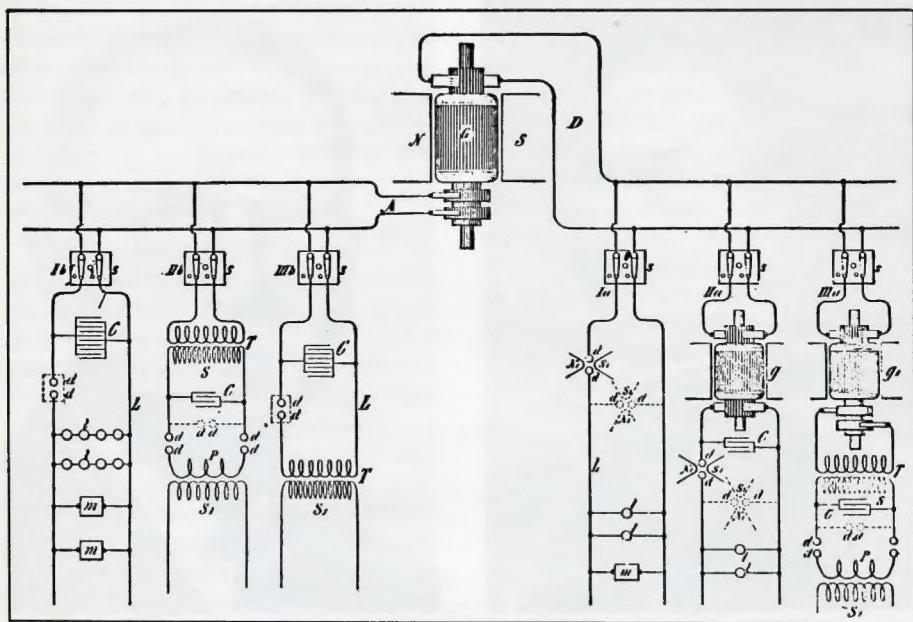


Figure 6 — These figures form Tesla's 1893 lecture were frequently cited as evidence supporting his claim of invention of radio.

paper on "Telegraphy Across Space," printed in the *Journal of the Society of Arts*, London, 1898, shows how Lodge had demonstrated the possibility of transmitting telegraph signals wirelessly by Hertzian waves at Oxford, in 1894, to a distance of 100 or 150 yards, and then goes on to state of Tesla's work: "Even before this, Mr. Nichola (Sic) Tesla, in a lecture delivered at St. Louis in 1893, had made a further suggestion of great importance. He proposed to transmit electric energy by oscillations to any distance, without communicating wires, by erecting at each end of the stretch a vertical conductor joined at its lower part to the earth, and at its upper to a conducting body of large surface. This constitutes a vertical base line from which to disseminate the oscillating disturbances."⁸

Lt. Commander Edward H. Loftin⁹ testified as follows concerning the lack of understanding by early workers in radio

of the mechanism of signal propagation: "As to the criticism of the extremely high elevated conductors mentioned by Tesla in a number of places when discussing the problem of transmitting large amounts of energy to great distances, he adequately disposes of this when it comes to the transmission of the small amount of energy necessary for transmitting intelligible messages--wireless telegraphy. On page 4 of the specification, lines 105 to 116, inclusive, he says: 'In some cases when small amounts of energy are required, the high elevation of the terminals, and more particularly of the receiving-terminal D', may not be necessary, since, especially when the frequency of the currents is very high, a sufficient amount of energy may be collected at that terminal by electrostatic induction from the upper air strata, which are rendered conducting by the active terminal of the transmitter or through which the currents from same are conveyed.'



Figure 7 — LCDR Edward H. Loftin, Naval Bureau of Engineering, Radio Research and Development.



Figure 8 — Major Gen. Joseph O. Mauborgne, Commanding Officer, Signal Corps radio laboratory.

"Therefore the matter of height of the elevated conductors was a matter of degree with Tesla, depending upon the amount of energy he wished to transmit... While Tesla has been severely criticized, yet every practical worker in the art today knows that the higher the elevated conductor the better is distance covered. This is the consideration that led to building towers, eight in number, each 850 feet high, for the Lafayette radio station in France, when, during the war, there was a possibility of the cables being cut by the German submarines, leaving radio communication as the only communication with the United States. To make communication over this great distance more certain night or day, winter or summer, the designers of the station undertook steel tower construction of unprecedented height in order to get the benefits of great height.

"This quotation has also been criticized because of Tesla's theory of the manner of transfer of the energy between the transmitting and receiving stations. After all it is merely theory, and since the authorities in this art are still groping and guessing at the real manner of transfer, there can be no objection to Tesla and other early workers in the art having different theories."¹⁰

Further, Major General Joseph O. Mauborgne¹¹ testified as follows: "While Mr. Tesla's conception of the transmitter shows conduction through the earth necessary, as Marconi did, for the transmission of energy to distant points on the earth's surface, there to be received by a synchronous device consisting of an elevated capacity area of vertical wire connecting the same to tuning elements consisting of self-inductance and capacity and a suitable earth connection for the purpose of receiving and reradiating in the case of his power experiments the energy supplied from the original transmitter, nevertheless he has described, in

parts of the book, quoted a perfectly operable transmitting system with suitable tuning devices and with a suitable receiving device having tuned circuits... He appreciated the necessity of synchronism and he taught the use of coupled circuits long before Marconi or Lodge."¹²

With regard to the criticism that the Tesla patent is not applicable to high frequency radio communication, the Court commented in its Opinion: "Tesla's specifications state that the current should preferably be 'of very considerable frequency.' In describing apparatus used experimentally by him, the specifications state that the oscillations are generated in the charging circuit by the periodic discharge of a condenser by means of 'a mechanically operated break,' a means whose effects are similar to those of the spark gap generally used at this period in the radio art. He further states that the inductance of the charging circuit is so calculated that the 'primary circuit vibrates generally according to adjustment, from two hundred and thirty thousand to two hundred and fifty thousand times per second.' The range of radio frequencies in use in 1917 was said by a witness for the plaintiff to extend from 30,000 to 1,500,000 cycles per second. The range of frequencies allocated for radio use by the International Telecommunication Convention, proclaimed June 27, 1934, 49 Stat. 2391, 2459, is from 10 to 60,000 kilocycles (10,000 to 60,000,000 cycles) per second, and the spectrum of waves over which the Federal Communications Commission currently exercises jurisdiction extends from 10 to 500,000 kilocycles. Code of Federal Regulations, Title 47, Ch. I, Par. 2.71. Thus Tesla's apparatus was intended to operate at radio frequencies."¹³

Finally, as to criticism that Tesla's patents were directed to wireless power transmission as opposed to signal communication, it should be noted that of the

various patents obtained by Tesla in the category of transmitting effects through the natural media, numerous patents are identified in the specification and claim sections as intended for signal communication and/or power transmission, or remote control, as shown in the table that follows:

Tesla, in patent #645,576, applied for September 2, 1897 and allowed March 20, 1900, anticipated the following features of the Marconi patent:

- a) A charging circuit in the transmitter for causing oscillations of the desired frequency, coupled, through a transformer, with the open an-

Tesla Patents: Transmitting Effects Through the Natural Media

| <u>Patent #</u> | <u>Application Filed</u> | <u>Granted</u> | <u>Signaling</u> | <u>Power</u> | <u>Remote Control</u> |
|-----------------|--------------------------|----------------|------------------|--------------|-----------------------|
| 613,809 | 07-01-98 | 11-08-98 | | | X |
| 645,576 | 09-02-97 | 03-20-00 | X | X | |
| 649,621 | 09-02-97 | 05-15-00 | X | X | |
| 685,012 | 03-21-00 | 10-22-01 | X | X | |
| 685,953 | 06-24-99 | 11-05-01 | X | X | |
| 685,954 | 08-01-99 | 11-05-01 | X | | |
| 685,955 | 06-24-99 | 11-05-01 | X | X | |
| 685,956 | 08-01-99 | 11-05-01 | X | | |
| 723,188 | 07-16-00 | 03-17-03 | X | | X |
| 725,605 | 07-16-00 | 04-18-03 | X | | X |
| 787,412 | 05-16-00 | 04-18-05 | | X | |
| 1,119,732 | 01-18-02 | 12-01-14 | | X | |

In his experiments at Colorado Springs in 1899, Tesla clearly produced vertically polarized waves,^{14, 15} but from ca. 1900 he devoted much attention to the transmission of power without wires. This phase of his work, because of its dramatic aspect, drew great attention in the press. His name has been identified with the original concept by those who have worked on this problem to the current times (1975). Unfortunately, Tesla's work was not extended because of his inability to acquire funds for continued research in highly speculative endeavor. In this context, it is inapropos for critics of Tesla's radio patents to cite his work in the field of wireless power transmission as the exclusive focus, dismissing thereby his work and patents on communication and signaling which preceded it.

In summary, the Court found that

tenna circuit, and

- b) the synchronization of the two circuits by the proper disposition of the inductance in either the closed or the antenna circuit or both.

"By this and the added disclosure of the two-circuit arrangement in the receiver with similar adjustment, he anticipated the four-circuit tuned combination of Marconi."¹⁶

As a contemporary worker in the field of radio with Tesla, Stone's acknowledgement of Tesla's work has perhaps a greater significance. In reviewing the work of Lodge, Marconi, Thompson and others he states: "Among all those, the name of Nikola Tesla stands out most prominently. Tesla with his almost preternatural insight into alternating current phenomena that has enabled him some years before

to revolutionize the art of electric power transmission through the invention of the rotary field motor, knew how to make resonance serve, not merely the role of a microscope, to make visible the electric oscillations, as Hertz had done, but he made it serve the role of a stereopticon... He did more to excite interest and create an intelligent understanding of these phenomena...than any one else...and it

has been difficult to make any but unimportant improvements in the art of radio telegraphy without traveling, part of the way at least, along a trail blazed by this pioneer who, though eminently ingenious, practical and successful in the apparatus he devised and constructed, was so far ahead of his time that the best of us then mistook him for a dreamer."¹⁷

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2. "Transcript of Record" for above case, p.38.
3. Op. cit., p. 979.
4. Loc. cit.
5. Op. cit., p.982.
6. "United States Reports," p.31 (footnote).
7. "Transcript of Record," p.858.
8. Op. cit., p. 861.
9. Chairman of Inter-Departmental Radio Board which hears radio patent cases, but otherwise Bureau of Engineering, Navy Department, in charge of radio research and development. Deposition taken January 21, 1924.
10. "Transcript of Record," p. 953.
11. Commanding officer of the Signal Corps radio laboratory. Deposition taken March 16, 1925.
12. "Transcript of Record," p. 1137.
13. "United States Reports," pp. 14, 15 (footnote).
14. H. M. Barlow, University College, London, in a personal communication to the author dated July 27, 1964: "...Tesla's magnifying transmitter produces, as I understand it, a horizontal electric field and a vertical magnetic field..."
15. J. R. Wait, NBS Laboratories, Boulder, in a personal communication to the author dated August 28, 1964: "...I find accounts of Tesla's work extremely fascinating if for no other reason that they predate by a long shot, all other electromagnetic research in Colorado ...I do believe he was launching vertically polarized ground waves..."
16. "United States Reports," pp.15, 16.
17. J. S. Stone, "Fames of Nikola Tesla" Liberty, Oakland-San Francisco, July 11, 1917.